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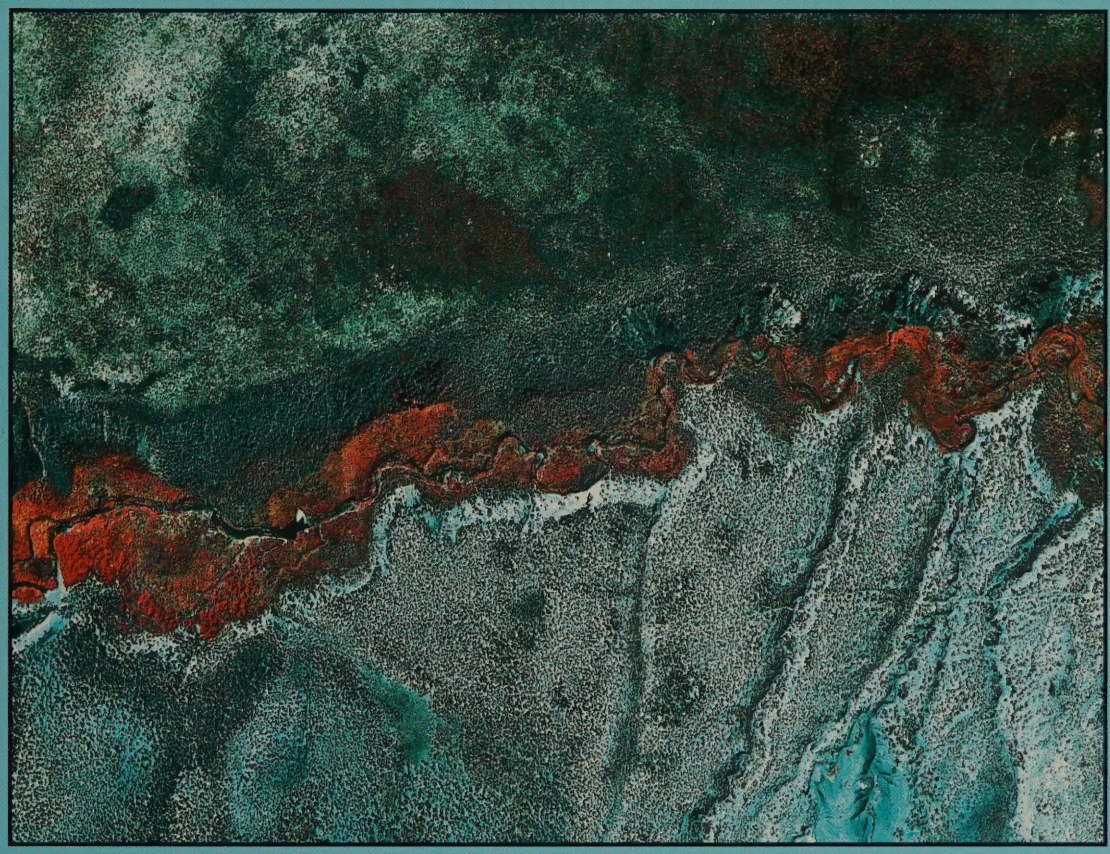

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RIPARIAN AREA MANAGEMENT

Using Aerial Photographs to Assess Proper Functioning Condition of Riparian-Wetland Areas

by

U.S. Department of the Interior
Bureau of Land Management
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Acknowledgements

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Using Aerial Photographs to Assess Proper Functioning Condition of Riparian-Wetland Areas

I. Introduction

Riparian-wetland areas, which comprise less than 9 percent of the total land base, are the most productive and important ecosystems found on lands managed by the Bureau of Land Management (BLM). Riparian-wetland areas are lands that display vegetative or physical attributes reflective of permanent water influence. Marshes, wet meadows, shallow swamps, estuaries, and lands adjacent to rivers, streams, and lakes are typical riparian-wetland areas. Characteristically, riparian-wetland areas display a greater diversity of plant and wildlife species and vegetation structure than adjoining ecosystems. Wildlife use riparian-wetland areas disproportionately more than any other type of habitat.

Healthy riparian-wetland areas are noted for having adequate vegetation, landform, or large woody debris to dissipate energy during high-flow events, limit erosion, and bolster water quality. Sound riparian-wetland areas also filter sediment and capture bedload, which aids floodplain development and enhances flood-water retention and ground-water recharge. In addition, healthy riparian-wetland areas produce diverse ponding and channel characteristics that provide habitat necessary for fish production, waterbird breeding, and other uses.

Riparian-wetland areas are highly prized for their economic values and diverse uses, such as livestock production and recreation. These values, uses, and resultant conflicts prompted BLM to develop a plan to manage riparian-wetland resources. The BLM's *Riparian-Wetland Initiative for the 1990's* (USDI, 1991) provides a blueprint for managing and restoring riparian-wetland areas on BLM managed lands. This intiative, which complements *Healthy Rangelands for All Uses* and other land management initiatives, takes an interdisciplinary approach to managing riparian-wetland areas.

Determining the condition of BLM's riparian-wetland areas is a meaningful step towards effective management of these important resources. BLM has developed many different tools to assist field offices in managing riparian-wetland areas. For example, aerial photography, along with other remote sensing techniques, provides useful data to make ecosystem-based and site-specific riparian-wetland management decisions. This baseline data, when carefully selected prior to a project, allows analysis of a larger area of interest, at a minimum cost, in less time per hectare than conventional on-the-ground methods (Clemmer, 1994).

The *Riparian-Wetland Initiative for the 1990's* also contains a strategy to focus management on the entire watershed. Knowing the condition of the watershed is an important component in assessing whether a riparian-wetland area is healthy.

II. Purpose

National goals and objectives for managing riparian-wetland areas on public lands are established in the BLM's *Riparian-Wetland Initiative for the 1990's*. The initiative's key goal, comprised of two parts, is to: 1) restore and maintain riparian-wetland areas so that 75 percent or more are in proper functioning condition (PFC) by 1997, and 2) achieve an advanced ecological status, except where resource management objectives, including PFC, would require an earlier successional stage, thus providing the widest variety of habitat diversity for wildlife.

To measure its progress towards accomplishing the above goal, the BLM has established two standard checklists to be used by field offices to assess condition of riparian-wetland areas. One checklist is designed for lotic riparian-wetland areas, and can be found in Technical Reference (TR) 1737-9, *Process for Assessing Proper Functioning Condition* (Prichard et al., 1993). The other checklist is designed for lentic riparian-wetland areas, and can be found in TR 1737-11, *Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas* (Prichard et al., 1994). The use of aerial photos and other remote sensing techniques can assist in this process by establishing baseline data and saving field offices time and money.

The purpose of this document is to provide field offices with a procedure for using aerial photography to answer PFC checklist items. This document supplements the above technical references, as well as TR 1737-10, *The Use of Aerial Photography to Manage Riparian-Wetland Areas* (Clemmer, 1994)

III. Background

During fiscal year 1994, discussions were conducted among the Great Divide Resource Area, the Service Center, the University of Wyoming, and the Wyoming State Office regarding the usefulness of aerial photography for assessing functioning condition of riparian-wetland areas. As a result of the discussions, a Photo Interpretation Team was formed to evaluate the feasibility of this type of assessment.

The Photo Interpretation Team's first task was to identify field sites where assessments using aerial photography could be tested. Field sites were identified in Colorado, Idaho, New Mexico, and Wyoming. Because only a limited number of sites could be visited, the initial field sites were narrowed down by applying the following criteria, in priority order:

1) A variety of film types and film scales were available for the site;

2) A variation of riparian-wetland area conditions relative to functionality were near the site;

3) A variety of riparian-wetland types were near the site; and

4) Where potential sites rated equally on criteria one, two, and three, travel and time constraints were considered.

The Team's final site selections included nine lotic sites and two lentic sites in Wyoming. Six lotic sites and two lentic sites were located in south-central Wyoming bordering Muddy Creek, Littlefield Creek, and McKinney Creek, and three lotic sites were located in north-central Wyoming bordering the Middle Fork Powder River and Buffalo Creek.

The Photo Interpretation Team's second task was to assess functioning condition of each field site from available aerial photos, including those recently obtained by the Rawlins District Office of the Muddy Creek drainage. The interpretation was done stereoscopically using optics with 4X magnification. A checklist was completed for each field site and an overall rating selected (PFC, functional—at risk, or nonfunctional).

A third task for the Photo Interpretation Team was to visit field sites to validate the completed checklists following the procedures identified in TR 1737-9 and TR 1737-11. Field validations were completed during the summer of 1995.

The Team's final task was to compare the results of the photo interpretations against the field validations. This analysis resulted in the development of a procedure to assess functionality of riparian-wetland areas using aerial photography.

IV. Photo Interpretation Procedure

The following procedure is intended to speed the process defined in TR 1737-9 and TR 1737-11. It involves having an interdisciplinary team preassess large areas by interpreting aerial photography, completing a PFC checklist, and, when necessary, visiting the field site. An interdisciplinary team ideally consists of specialists in the areas of hydrology, geology/geomorphology, remote sensing, photo interpretation, biology, and vegetation. The considerable prework involved cuts down on field time and allows work to be accomplished during those times when field sites are not accessible.

A. Gather Existing Source Material

Any existing source material should be gathered prior to beginning the interpretive process. The knowledge of individual team members about an area under investigation is a valuable component of the assessment. Existing inventory data aids in the interpretation and adds another dimension to the interpreters' ability to accurately assess an area's condition. Previous data collected may also provide indications of prebaseline condition and subsequent trend. Ancillary source material may take several forms.

1. Tabular and Other Hard-Copy Data

Inventory data collected in the past is a great asset to any photo interpreter. Field files and databases containing information pertaining to the sites are important sources of input. They provide a way to obtain field verification without actually visiting a site. Photos keyed to data provide a valuable source for building a photo interpretation key, such as the example in Appendix A.

Topographic map coverage of a study area should be acquired by the interdisciplinary team from the U.S. Geological Survey (USGS). The 7.5 minute, 1:24,000 scale series is recommended for this application. These maps are used for creating a photo index of coverage for ease in locating position on photos, for delineating reaches to be assessed, and for frequent reference during the interpretation process.

Orthophotography is a valuable tool to use in conjunction with a topographic map. Orthophotos are available in a 7.5-minute, 1:24,000 scale matching the topographic maps, but have a differentially rectified black-and-white image rather than the standard topographic contours. Orthophotos can be obtained from the Earth Science Information Center (ESIC) at USGS in Denver, Colorado.

2. Photos

The interdisciplinary team should conduct a search to determine the best available photos for a project. Many field offices already have photos available, but these photos may not be the best selections for conducting the assessment.

Aerial photo searches can be conducted by contacting a BLM State Remote Sensing Coordinator, the BLM National Applied Resource Sciences Center in Denver, or the ESIC. Searches are usually conducted by 7.5-minute topographic quadrangle and result in a list of available photos from various government agencies and private companies. The list includes scale, film type, and date of acquisition. When ordering photos, adequate time for delivery, which can take 6 to 8 weeks, should be allowed.

Appropriate photos should be selected according to the following guidelines:

- For this application, the most current photos generally yield the most accurate results. However, older photos should not be ignored, as they can provide clues to prior condition and trend. Other factors may influence the date of photography selected (e.g., film type, scale). For example, color infrared (CIR) film dated July 1993 would probably be a better choice than black-and-white (BW) film dated September 1995.

  NOTE: Aerial contracts flown specifically for PFC assessment should not be considered due to cost and time restrictions. If contracts are being considered for other purposes, the PFC application requirements could be included in those contracts (i.e., film type, scale).

- CIR photos are preferable because they allow interpreters to detect subtle differences in vegetation due to the spectral reflectance of the film. Natural color (NC) photography can be used, but spectral reflectance is less than that for CIR. TR 1737-10 provides examples of NC and CIR photos.

- A photo scale that is small enough to expedite the interpretation task, but large enough to interpret the detail needed, should be selected. In most cases, a scale of 1:40,000 is adequate for this type of interpretation. This scale provides a synoptic view of the area and gives a better perspective of general landform characteristics. Using a smaller scale is also the most efficient way to assess large areas in a cost-effective manner. Smaller problem areas should be approached using larger scale imagery when needed (e.g., 1:3,000- to 1:24,000-scale). TR 1737-10 provides examples of different photo scales of the same area. In addition, larger scale photography can always be acquired as an enlargement if desired.

  NOTE: The scale selected is directly influenced by the type of optical equipment that is available for use in interpretation (see Section B).

- Film transparencies are more easily interpreted than paper prints. Transparencies are more expensive, but worth the cost for the added sharpness and clarity that they provide. Detail at smaller scales is easily interpreted when viewed on a film transparency. However, one drawback to film transparencies is that they must be used on a light table and cannot be used easily in the field.

Once photos have been received, team members should compile a photo index. A photo index simply shows the approximate location of each frame of photography on a topographic map. Indices are usually compiled on overlay material registered to a 7.5-minute map (Figure 1). Although this process is somewhat time-consuming, a photo index assists the interpreters in locating position on the photo and helps keep track of project photography.

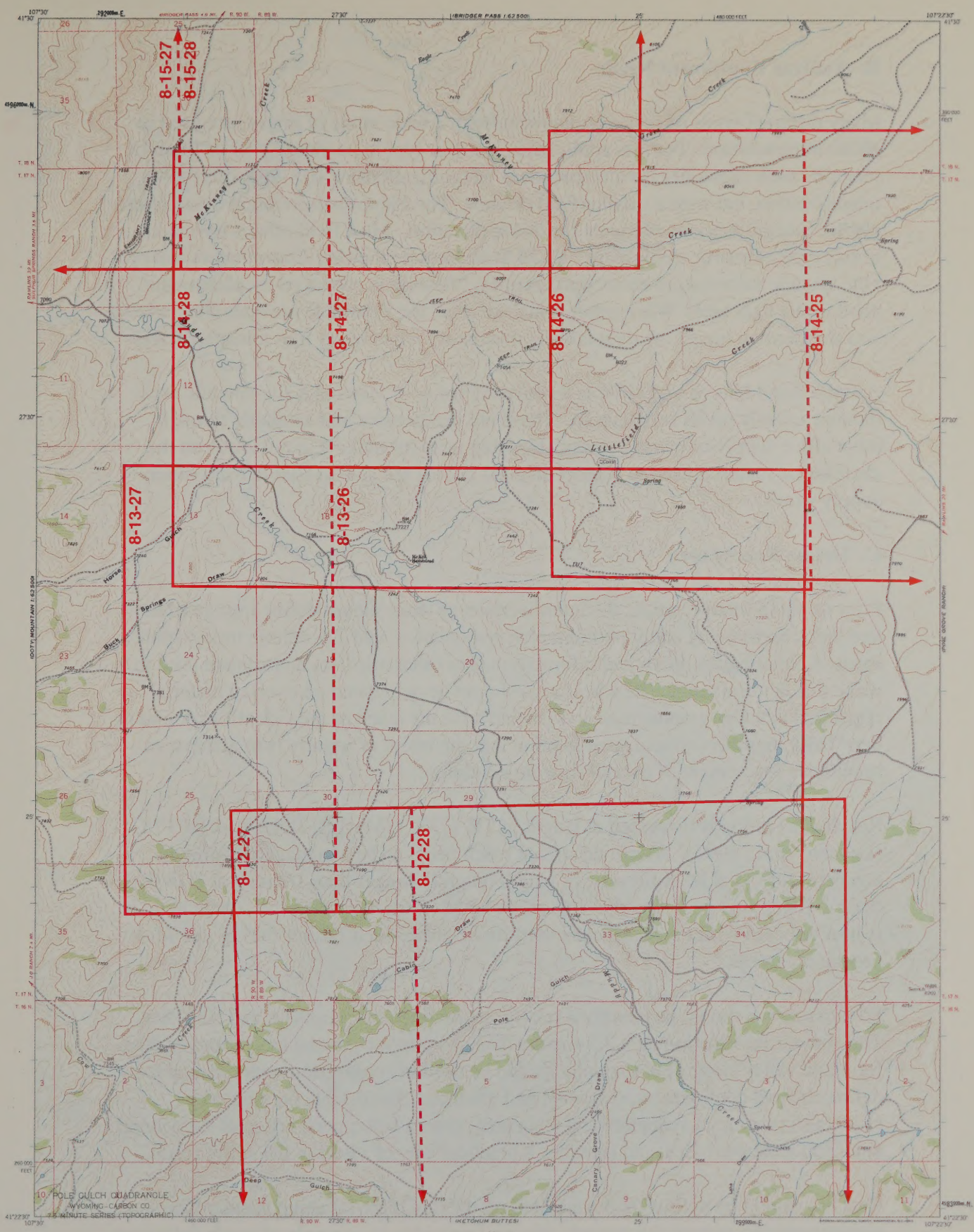

Figure 1.

Suggestions:

1. Annotate roll-flight-exposure number on each frame.
2. Annotate on the same side as film (west edge in this example); that way you can easily determine which way to orientate north.
3. Show overlap between photos with dashed line.
4. Always put corner ticks & quad name on each overlay.
5. If more than one project or scale photography was used, draft index in separate colors for easy differentiation.

Scale 1:24,000 Pole Gulch, WY
Project WY82A1 41107-D4
Film color infrared
Date 7/16/82

B. Analyze Equipment Needs

Many different types of optical equipment, with a wide range of prices, are used in photo interpretation. For this application, a mirror type stereoscope with at least 4X magnification capability is recommended. Magnifications of 10X-20X offer more magnification, but with a smaller field of view. The Photo Interpretation Team found 4X-10X magnifications adequate for this application. Most field offices have access to this type of mirror stereoscope. BLM State Remote Sensing Coordinators can provide specific information about stereoscopes. Viewing is enhanced by placing the photos on a light table. When paper prints are used, the light table provides backlighting and sharpens an image. A light table is mandatory when using film transparencies.

A single hand lens or magnifier is a convenient way of viewing a site-specific area monoscopically on an aerial photo. These are inexpensive and available through most office supply or camera stores. Drafting pens for making annotations on the clear mylar material used to protect original photos are also available from office supply stores.

C. Define Reach/Area

Prior to photo interpretation, the interdisciplinary team should define lotic reaches and lentic areas using aerial photography, orthophotos, and 7.5-minute topographic maps. Climatic data, historical information, and other ancillary sources are used to make this determination. Reaches/areas should be delineated on overlay material registered to a topographic map and labeled with the reach or area identification number. Team members should keep in mind that the intent of a study is to achieve an immediate assessment of overall riparian condition.

Reach delineation is discussed at length in TR 1737-3 (Meyers, 1989) and TR 1737-7 (Leonard et al., 1992). A defined stream reach needs to be a manageable unit that, as a general rule, is at least 1/4 mile in length (slightly longer than 1/2 inch at 1:24,000 scale). Using this guideline prevents reach length from becoming too segmented. It is best to begin with longer reaches that can be subdivided further during the interpretation process.

Stream reaches should be identified relative to confinement, gradient, and sinuosity. The contour information on a 7.5-minute map can provide general indications of landform and valley slope. Photography should be used in conjunction with the map to define channel confinement, sinuosity, and gradient. Small-scale photography (1:40,000) provides a synoptic view of an area, gives a better perspective of the general landform characteristics, and provides a practical way of viewing the entire reach.

Reaches should be defined and annotated on overlay material using standard naming conventions throughout the project. Figure 2 provides an example of reach definition for one quad. Forethought should be given to naming conventions that allow subsequent input to a Geographic Information System (GIS) for graphic query capabilities based on functionality.

Figure 2.

Suggestions:

1. Beaver ponds are treated as part of the lotic system (see a, b, and c).
2. Reach definition is standardized working from the bottom of the reach to the top.
3. Reach numbers should be annotated on each checklist along with the 7.5-minute map name and photo number (roll-flight-exposure).

Third attribute indicates number of reach or site on quadrangle

W	= wetland (lentic)	Pole Gulch, WY
R	= riparian (lotic)	41107-D4
M	= Muddy Creek	
K	= McKinney Creek	
G	= Grove Creek	
L	= Littlefield Creek	
C	= Cow Creek	
Ø	= No name	

D. Interpret Aerial Photos

Clear overlay material should be attached to each photo for protection, and fiducials, identification format, and beginning and endpoints of each reach or area should be clearly marked on the overlay material. Fiducials are the camera registration marks found on each side of the photo and in the corners. The identification format is the textual information along one side of the photo. This information usually gives the date of photography, project code, nominal scale, and roll-flight-exposure number (see TR 1737-10). Marking fiducials and identification format onto overlays allows them to be removed and reregistered later without damaging the original photo.

A PFC checklist should be prepared for each reach/area, with the photo number, reach delineation number, and date recorded on each checklist. A general photo interpretation key, such as the example in Appendix A, should be developed for the assessment. Using a key during photo interpretation ensures that team members are answering checklist items using the same set of criteria. A key also assists in feature identification so that the interpreters are confident in the decisions made. Various elements listed in the key are intended to be generic and may need to be expanded upon based on a specific ecoregion. Appendix B provides photo samples with explanations of elements from the key. Prior to beginning the assessment, all team members should familiarize themselves with the key and discuss any changes or alterations that may need to be made for a specific area. The key should be revisited frequently during interpretation to maintain consistent interpretations.

Organizing the stereo photo pairs will facilitate the interpretation process. A stereo pair for a reach/area should be set up under a mirror stereoscope. Team members should study the reach/area and consider how to answer a PFC checklist item. Each item should be discussed individually and rated based on the interpretation key. When there is disagreement on an item, a "?" should be written in both columns of the checklist (Figure 3). Notes should be made regarding issues in question; larger scale photos may help answer these checklist items, or team members may need to visit a field site for verification. If the condition appears to change midway on a reach, interpreters should state why they feel the condition changed (e.g., active headcut). After all items are discussed and a PFC checklist completed, team members should determine an overall rating for a site.

Team members' field knowledge is important in answering some checklist items when using aerial photography. A combination of field experience and training in photo interpretation is critical to the success of this endeavor.

Standard Checklist*

Name of Riparian-Wetland Area: Muddy Creek - Site 1

Date: March 6, 1995 Area/Segment ID: Pole Gulch, Wyoming/41107D4

Miles: 1.5

ID Team Observers: Mark Gorges, Don Prichard, Gretchen Meyer, Karen Shumac, Pam Clemmer

Photo Number: NAPP 1735-13 Date: 7/2/89 Film Type: CIR Scale: 1:40,000

Yes	No	N/A	Hydrologic
x			1) Floodplain inundated in "relatively frequent" events (1-3 years)
	x		2) Active/stable beaver dams
?	?		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	x		4) Riparian zone is widening or has achieved potential extent
x			5) Upland watershed not contributing to riparian degradation
Yes	**No**	**N/A**	**Vegetative**
	x		6) Diverse age-class distribution (recruitment for maintenance/recovery)
	x		7) Diverse composition of vegetation (for maintenance/recovery)
	x		8) Species present indicate maintenance of riparian soil moisture characteristics
	x		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events
?	?		10) Riparian plants exhibit high vigor
	x		11) Adequate vegetative cover present to protect banks and dissipate energy during high flows
		x	12) Plant communities in the riparian area are an adequate source of coarse and/or large woody debris
Yes	**No**	**N/A**	**Erosion Deposition**
?	?		13) Floodplain and channel characteristics (i.e., rocks, coarse and/or large woody debris) adequate to dissipate energy
x			14) Point bars are revegetating
x			15) Lateral stream movement is associated with natural sinuosity
x			16) System is vertically stable
	x		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

* This example is for a lotic site (TR 1737-9). Use TR 1737-11 checklist for lentic sites.

Figure 3.

V. Recommendations

Aerial photography can be used to assess PFC, but there are limitations. The following recommendations can help ensure success in applying this technique:

- When possible, CIR film should be used rather than NC or BW film. CIR film allows the interdisciplinary team to make vegetation interpretations at a smaller scale.

- A cost/time analysis should be done when selecting a scale (see Appendix C). Though larger scale (1:3,000) photos are easier to interpret, more photos are required to cover the same area as one small-scale (i.e., 1:40,000) photo. Most PFC checklist items can be answered using small-scale, CIR photos.

- Positive transparencies used on a light table are far superior to paper prints. Many features not discernable on prints are easily detected on transparencies. However, transparencies are more costly than prints (Appendix C).

- Photos taken in mid- to late summer should be selected to assure accurate signatures of vegetation, width/depth ratios, and erosion deposition.

- Photos that are as current as possible and that meet the above criteria should be selected.

- Field experience and training in photo interpretation, as well as practice on some sites before starting the process, are mandatory for team members.

- This process should be used as an initial cut at assessing PFC. It is a tool that assists in focusing on problem areas which should be visited on the ground to verify interpretations.

VI. Summary

The Photo Interpretation Team found that aerial photos can be used to assess functioning condition of riparian-wetland areas. Success in applying this procedure is related to the recommendations listed in this document. Training in photo interpretation, field experience, and knowledge of field sites assessed are also very important.

This procedure should be used as an initial cut at assessing PFC. Like any tool, the application of photo interpretation has its limitations. When disputes arise among team members, a field visit may be necessary to complete an assessment.

The Photo Interpretation Team also found that lentic riparian-wetland areas are easier to assess than lotic riparian-wetland areas. Most lentic areas are confined to a smaller area, which allows team members to examine and interpret the entire site. Many lotic riparian-wetland areas are narrow and set in landforms (e.g., canyons) that make photo interpretation more difficult.

Photos from the National Aerial Photography Program (NAPP), when taken with CIR film, were found to be the most cost-effective to use for answering PFC checklist items. Even though individual features are not as obvious at the 1:40,000 scale, most checklist items could be interpreted. NAPP photos are usually taken on a 7-year cycle and can be used to establish baseline data. Photos from subsequent flights can be compared for trend and monitoring purposes.

Aerial photography may not be the only other possible means by which to assess PFC. Videography is an up-and-coming technology that may be used for this application. Videography may provide a cost-effective, timely means of acquiring assessment imagery. The BLM's Prineville District Office is exploring the efficiency of videography for this purpose. Similar efforts are being explored on the Virgin River in Arizona, Nevada, and Utah; on the Arkansas River in Colorado; and on a number of streams in Arizona.

Results gathered from any riparian-wetland PFC assessment should be put into a database for followup studies.

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Glossary of Terms

Color Infrared Film - A three-layer color film sensitized to green, red, and near-infrared. Conventional natural color film is sensitive to blue, green, and red.

Fiducial Marks - Index marks, rigidly connected with the camera lens through the camera body, which form images on the film. Usually there are eight, with one in each corner and one on each side of the image frame.

Functional—At Risk - Riparian-wetland areas that are in functional condition, but an existing soil, water, or vegetation attribute makes them susceptible to degradation.

Nonfunctional - Riparian-wetland areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows and thus are not reducing erosion, improving water quality, etc. The absence of certain physical attributes, such as a floodplain where one should be, are indicators of nonfunctioning conditions.

Proper Functioning Condition (PFC) - Riparian-wetland areas are functioning properly when adequate vegetation, landform, or large woody debris is present to dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize streambanks against cutting action; develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and support greater biodiversity.

Spectral Reflectance - Electromagnetic radiation at specified wavelength intervals.

Signature - Any characteristic or series of characteristics by which a material may be recognized. Used in the sense of spectral signature (i.e., differences in electromagnetic wavelength).

Appendix - A

Photo Interpretation Key

NOTE: This key was developed based on the use of CIR film. The spectral characteristics inherent in CIR photos are a critical part of some interpretation keys. This key is an example and should not be considered complete.

HYDROLOGIC

1. Floodplain inundated in "relatively frequent" events (1-3 years).
   - Evidence of matted vegetation and debris on the active floodplain.
   - Active floodplain (first terrace) is close to the same level as the stream.
   - Absence of steep vertical banks adjacent to the active channel.
   - Bright red spectral response of vegetation next to the water in CIR photos.

2. Active/stable beaver dams.
   - Ponding or widening of stream with associated dams across channel.
   - Abandoned dams are vegetated, evidenced by reddish signature.
   - Signs of building, ponding, silting in, with evidence of grasses, sedges, or rushes.

3. Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting, (i.e., landform, geology, and bioclimatic region).
   - Stream meanders across full width of valley floor.
   - Good sinuosity in relation to valley width and slope.
   - Active channel is narrow and deep (black reflectance) rather than wide and shallow (blue-green reflectance).

4. Riparian zone is widening (reference historical photography for comparison).
   - Riparian vegetation (bright red in CIR) is replacing upland vegetation (greenish to bluish).
   - Young riparian vegetation is capturing streambanks.
   - Fullest width has been achieved.

5. Upland watershed not contributing to riparian degradation (look at area from a small-scale perspective).
   - Alluvial fans from side drainages excessive (gray or white signature on CIR).
   - Excessive deposition from uplands.

VEGETATION

6. Diverse age structure of vegetation.
   - Variation in spectral signatures of vegetation.
   - Variation in textural pattern for new to old growth (2-3 age classes).
   - Variation in height.

7. Diverse composition of vegetation.

   - Variation in spectral signatures of vegetation.
   - Variation in textural pattern.
   - Variation in height.

8. Species present indicate maintenance of riparian soil moisture characteristics.

   - High spectral reflectance in infrared bands (bright red color late in the growing season).
   - Presence of high moisture communities, e.g., sedges, rushes, willows, cattails (OBL or FACW species - TR 1737-11).

9. Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events.

   - Presence of stabilizing, woody species, e.g., willows and cottonwoods.
   - High spectral reflectance in infrared bands (bright red color late in the growing season).

10. Riparian plants exhibit high vigor.

    - Deep red spectral signature in infrared bands.
    - High soil reflectance indicating drying conditions not evident in infrared bands.
    - White to yellow signature indicating unhealthy vegetation not evident in infrared bands.

11. Adequate vegetative cover present to protect banks and dissipate energy during high flows.

    - Streambanks are well-vegetated with riparian species (bright red color in CIR along most of streambank late in the growing season).
    - Soil disturbances (e.g., slumping) not evident.
    - Excessive bare soil on streambanks (white to grayish reflection) not present.

12. Plant communities in the riparian area are an adequate source of coarse and/or large woody debris (trees, conifers, etc., along forest streams in the Northwestern U.S.).

    - Evidence of woody debris on floodplain and/or channel that can act as a hydrologic modifier.

EROSION/DEPOSITION

13. Floodplain and channel characteristics (i.e., rocks, coarse and/or large woody debris) adequate to dissipate energy (relative to potential).

    - Presence of rock and/or large woody debris in channel and floodplain.
    - Presence of active overflow channels, back-water areas, oxbows.

14. Point bars are revegetating.

    - Red spectral reflectance in infrared bands on point bars.
    - Presence of young riparian vegetation on point bars.

15. Lateral stream movement is associated with natural sinuosity.

    - Natural channel migration is evident.
    - Point bars are revegetating with lateral movement.
    - Single channel systems should not show braiding.

16. System is vertically stable.

    - Headward erosion (headcuts) not evident.
    - Presence of healthy, vigorous riparian vegetation exhibiting a reddish signature.
    - Presence of geologic controls (i.e., bedrock).

17. Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition).

    - Water appears black in infrared band, indicating little sediment.
    - Excessive erosion or deposition (gray to white reflectance) not evident (i.e., blowouts and midchannel bars).

Appendix - B

Photo Interpretation Examples

Photo 1a — July 1989

Photo 1b — July 1989

McKinney Creek - Wyoming

Photo 1a is a CIR photo of McKinney Creek at a nominal scale of 1:40,000. Photo 1b is a 2X enlargement of photo 1a (approximately 1:20,000). In photo 1b, the stream is wide and shallow, indicating that its width/depth ratio is not in balance with its landscape setting (arrow 1).

The white reflectance (arrow 2) identifies lateral and point bars that are not vegetated. If lateral and point bars were vegetated, they would exhibit a bright red signature indicating healthy riparian-wetland vegetation. A light pink to gray signature (arrow 3) indicates primarily upland vegetation. All vegetation items on a PFC checklist would receive a "No" response.

The presence of midchannel bars (arrow 4) suggests that the floodplain and channel characteristics are not adequate to dissipate energy. Deposition of materials also indicates the system is not in balance with its sediment load.

The color balance difference in the two photos should be noted. Color balance in CIR photography is difficult to control.

Photo 2a — July 1989

Photo 2b — August 1993

Littlefield Creek - Wyoming

Photo 2a is a CIR photo of Littlefield Creek at a nominal scale of 1:40,000, photo 2b is a CIR photo at a nominal scale of 1:24,000, and photo 2c is a ground photo. All three photos focus on a headcut (arrow 1) that is slowly progressing upstream through a beaver complex.

This stream would be divided into two reaches, one above the headcut and one below, based on evidence in these photos. The disturbance caused by the headcut can be seen in all three photos.

Bright red signatures (arrow 2) reflect healthy riparian-wetland vegetation. Below the headcut, the white signature (arrow 3) indicates bare streambanks. With a stereoscope, the incision of the channel can be seen.

Photos 2a and 2b show a series of beaver ponds (arrow 4). Ponding in photo 2a, a broader riparian zone associated with ponding, and structure of woody vegetation are clues that tell an interpreter that beaver are present. Careful examination with stereo magnification of 1:40,000 photos will show dams stretching across Littlefield Creek.

Under stereo magnification, diverse age structure of vegetation (arrow 5) can be seen around the beaver ponds in aerial photos 2a and 2b. Variations in texture, height, and spectral reflectance are indicators of a diverse composition and age structure of vegetation. Some diversity can still be seen below the headcut (arrow 6). However, the mixed red, white, and blue-green signatures are indicators of upland species that have invaded the site due to lowering of its water table.

On a standard PFC checklist, items addressing vegetation above the headcut would be answered "Yes;" items addressing vegetation below the headcut would be answered "No."

Photo 2c — June 1995

Photo 3a — July 1989

Photo 3b — August 1993

Middle Fork Powder River - Wyoming

Photo 3a is a CIR photo of the Middle Fork Powder River at a nominal scale of 1:40,000. Photo 3b is an NC photo of the same area at a nominal scale of 1:3,000. Photo 3c is a field photo taken from a ledge approximately 200 feet above the valley floor. This series of pictures shows how landform is important in determining the condition of a riparian-wetland area.

Under stereo magnification, unvegetated spots (arrow 1) can be seen in the channel in photo 3a. The slope of the valley bottom and the gradient of the stream suggest that these could be rock rather than sand, gravel, or soil bars; the other two photos confirm the presence of large rocks and possible bedrock in the channel.

Vegetation items on a PFC checklist could be answered "N/A" or "Yes" because vegetation plays a limited role in dissipating stream energy.

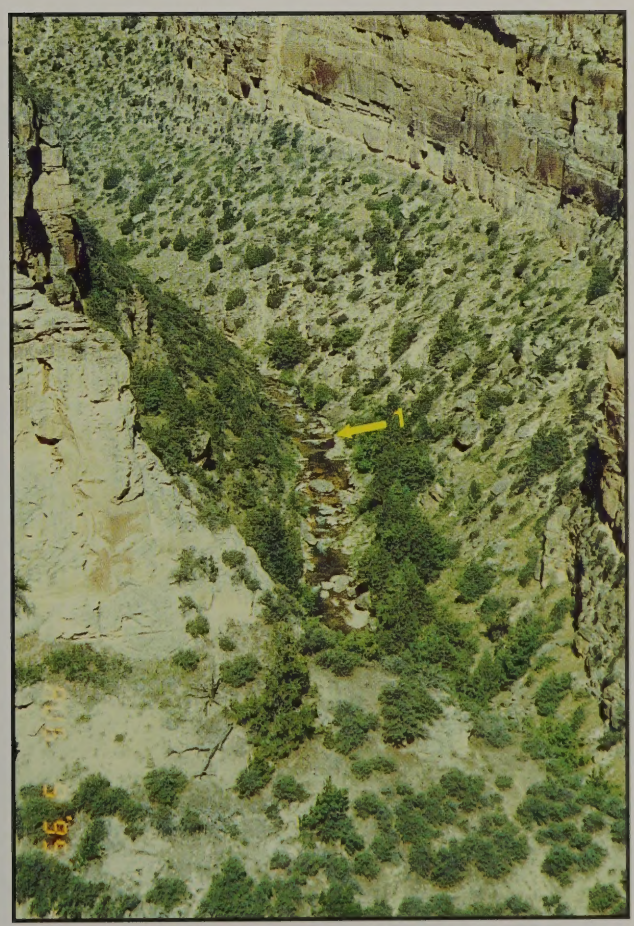

Photo 3c — June 1995

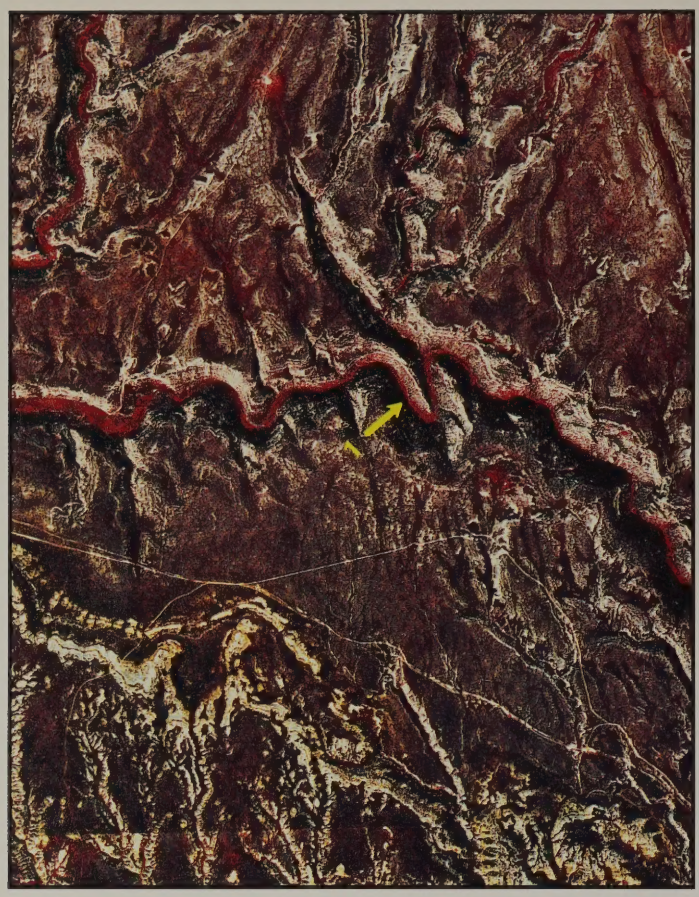

Photo 4a — June 1989

Photo 4b — August 1991

Buffalo Creek - Wyoming

Photo 4a is a CIR photo of Buffalo Creek at a nominal scale of 1:40,000. Photo 4b is an NC photo of the same area at a nominal scale of 1:3,000. Photo 4c is a ground photo.

Photo 4a shows a bright red signature throughout the valley floor due to a wet year (arrow 1). This would be interpreted as excellent riparian-wetland vegetation condition throughout the reach. However, an interpreter must compensate for photos that were taken while upland species are still actively growing. Photos 4b and 4c show that there is a high percentage of upland vegetation, especially grasses, growing on the streambanks (arrow 2). Upland plants do not count when deciding if there is adequate vegetation to protect streambanks. Vegetation items on a PFC checklist would be answered "No."

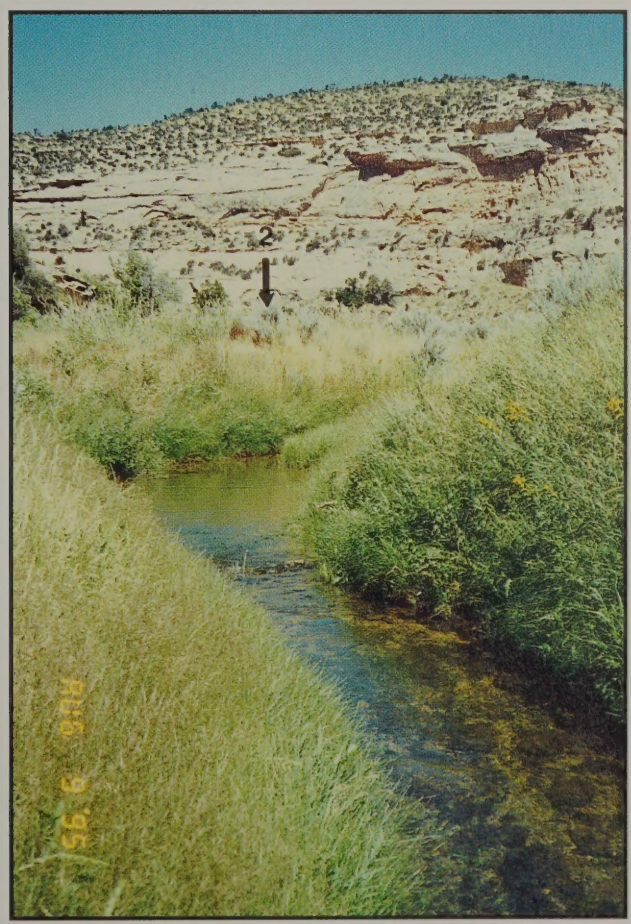

Photo 4c — August 1995

Appendix - C

Imagery Comparisons

Below are comparisons among the types of imagery used in this project. There are other types of film and many different scales of aerial photography available for the Western United States.

	1:40,000	1:31,680	1:24,000	1:15,840	1:6,000	1:3,000	Comments on media characteristics
Linear coverage per photo (miles)	5.7	4.5	3.4	2.25	0.85	0.43	9- x 9-inch photos with 60% overlap for stereo
Area coverage per photo (sq. miles)	32.5	20	11.5	5	.72	.18	
Cyclic coverage	Yes (5-7 yrs. NAPP)	no	no	no	no	no	Cyclic provides historical coverage
General use	resource	resource	resource	resource	site-specific	site-specific	
Resolution (feet)	8-10	6-7	5-6	2-3	0.75-0.85	0.25	Positive transparencies provide sharper image
Film type: NC, CIR, BW	BW, CIR	CIR	NC, CIR	NC	NC, CIR	NC, CIR	CIR best for vegetation interpretation
Cost per photo*	$3/print-BW $8/print-CIR	$8/print $12/film	$1/print-NC $8/print-CIR	$1/print	$1/print-NC $8/print-CIR	$1/print-NC $8/print-CIR	$25 per roll color balance charge
Comments on imagery	National program	2 inches = 1 mile	same scale as 7.5-minute map	4 inches = 1 mile	good detail and resolution w/limited ground coverage		

* All costs stated are approximate.

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This technical reference provides a process for using aerial photos to assess functioning condition of riparian-wetland areas, thereby reducing field time and costs.

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